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Docket No. : **TMBR-P004****APPLICATION TRANSMITTAL LETTER**

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ATTN: BOX PATENT APPLICATION

Sir:

Transmitted herewith for filing is the patent application of

Inventor(s): **JAKATDAR, et al.**Entitled: **"SYSTEM AND METHOD FOR REAL-TIME LIBRARY GENERATION OF GRATING PROFILES"**25 No. pages of specification, including title page, claims and abstract11 No. sheets of X informal, formal drawings

Also enclosed are:

- X Unexecuted Combined Declaration and Power of Attorney for Patent Application
X An Original Executed Assignment of the Application
 Form PTO-1595 (Recordation Cover Sheet for Assignment)
X Verified Statement Claiming Small Entity Status with Cover Sheet
 An Information Disclosure Statement (Form PTO-1449A and Form PTO-1449B)
 A copy of References cited in Information Disclosure: document

FEES DUE

The fees due for filing the application pursuant to 37 C.F.R. 1.16 and for recording the Assignment, if any, are determined as follow:

CLAIMS					
	No. of Claims		Extra Claims	Rate	Fees
Basic Application Fee (\$710 large entity; \$355 small entity)					\$ 355.00
Total Claims	33	Minus 20 =	13	X \$18 =	
				X \$ 9 (small) =	117.00
Total Independent Claims	14	Minus 3 =	11	X \$78 =	
				X \$39 (small) =	429.00
If Multiple Dependent Claims are presented, add \$260.00 or \$130.00(small)					
If Assignment enclosed, add Assignment Recording Fee \$40.00					40.00
TOTAL APPLICATION FEE DUE					\$ 941.00

PAYMENT OF FEES

The full fee due in connection with this communication is
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This application is filed pursuant to 37 C.F.R. 1.53 in the name of the above-identified Inventor(s).

Please direct all correspondence concerning the above-identified application to the following address:

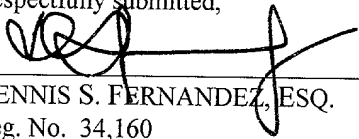
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22877
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Respectfully submitted,



DENNIS S. FERNANDEZ, ESQ.
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11/28/2000

Date

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of :

Application No.: (Not yet assigned)
Filed: 11/28/2000

Group No.: (Not yet assigned)
Examiner: (Not yet assigned)

Title: **"SYSTEM AND METHOD FOR REAL-TIME LIBRARY GENERATION OF GRATING PROFILES"**
Inventor(s): **JAKATDAR, *et al.***

Assistant Commissioner for Patents
Washington, D.C. 20231

**SUBMISSION OF VERIFIED STATEMENT
TO ESTABLISH SMALL ENTITY STATUS**

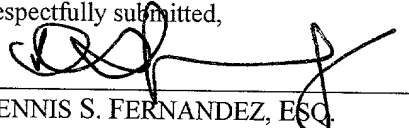
The attached statement is being submitted to establish small entity status in this

☒ Application
☐ Patent

by the

☐ Independent inventor(s) 37 CFR 1.9(c) and 1.27(b)
☐ Non-inventor supporting claim by another 37 CFR 1.9(c) and 1.27(b)
☒ Small Business Concern 37 CFR 1.9(d) and 1.27(c)
☐ Nonprofit Organization 37 CFR 1.9(e) and 1.27(d)

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.: (Not yet assigned)Patent No.: (Not yet assigned)Filed on: 11/28/2000Issued on: (Not yet assigned)Title: **"SYSTEM AND METHOD FOR REAL-TIME LIBRARY GENERATION OF GRANTING PROFILES"**Inventor(s): **JAKATDAR, N.****VERIFIED STATEMENT CLAIMING SMALL ENTITY STATUS**
(37 CFR 1.9(f) and 1.27(c) -- SMALL BUSINESS CONCERN)

I hereby declare that I am

 the owner of the small business concern identified below: X an official of the small business concern empowered to act on behalf of the concern identified below:

Name of Small Concern:

TIMBRE TECHNOLOGIES, INC.

Address of Small Concern:

**5341 Randall Place,
Fremont, CA 94538**

I hereby declare that the above identified small business concern qualifies as a small business concern, as provided in 37 CFR 1.9(d), for purpose of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons.

I hereby declare that the rights under contract or law have been conveyed to, and remain with, the concern identified above with regard to the invention described in

 X the specification filed herewith, with title and inventor(s) as listed above. the application identified above. the patent identified above.

If the rights held by the above identified concern are not exclusive, each individual, concern, or organization having rights in the invention is listed below and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c), it that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

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or any maintenance fee due after the date on which status as a small business entity is no longer appropriate.
(37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further, that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

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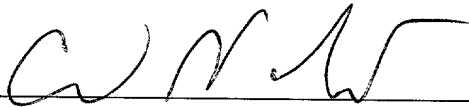
Chief Executive Officer

Title of Person Signing

TIMBRE TECHNOLOGIES, INC 5341 Randall Place, Fremont, CA 94538

Address of Person Signing

SIGNATURE



Date

11/27/00

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Application

For

10

United States Utility Patent

Title:

**SYSTEM AND METHOD FOR REAL-TIME LIBRARY
GENERATION OF GRATING PROFILES**

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Inventor(s):

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SYSTEM AND METHOD FOR REAL-TIME LIBRARY GENERATION OF GRATING PROFILES

BACKGROUND OF INVENTION

Field of Invention

Invention relates to the measurement of dimensions in gratings and more particularly to the generation and use of configurable libraries of grating profiles.

Description of Related Art

Features on semiconductor devices and transmitters of optical fiber links are being formed that are less than one micron in width. Measurement of these sub-micron features is increasingly difficult as the size of the features become smaller. However, knowledge of the dimensions of gratings or periodic structures is essential in order to determine if the dimensions of the features are within the acceptable ranges and if a particular fabrication process causes the sidewalls of the features to be tapered, vertical, T-topped or undercut.

Traditionally, a sample was cleaved and examined with a scanning electron microscope or similar device. This method is slow, expensive, and only provides one measurement number seen from the top of the feature. Angular scatterometry have been employed to measure linewidths of gratings but the process requires a setup of multiple detectors at different angles from the incident beam to measure the diffraction of the scattered light. Again, this is difficult to implement because of the setup required.

Spectroscopic reflectometry and ellipsometry are used to beam light on the grating and measure the spectra of reflected signals. Current practices basically use an empirical approach where the spectra of reflected light is measured for a known width of features in a grating. This process is time consuming and expensive even for a limited library of profiles of grating dimensions and the associated spectrum data of reflected light. There

is a need for a less laborious and less expensive method of creating the library of profiles and associated spectrum data.

Furthermore, if such a library were built for a wide range of profiles, it would be very useful to have access and use of the library in a real-time environment. An extensive library of profiles and spectrum data would however be inefficient for searching purposes needed for real-time work. For a short fabrication run, a client may only need a small subset of the extensive master library. Thus, there is a need for a method and system of providing libraries of grating profiles that are responsive to both long term and short term requirements of the client.

SUMMARY OF INVENTION

Invention resides in a method and a system for creating configurable libraries of grating profiles and spectrum data. The method comprises specifying a parameter set of a plurality of dimensions of a grating and compiling a master library of grating profiles corresponding to the combinations of the parameter set of the plurality of dimensions at different resolutions and the calculated spectrum data.

One embodiment is a system for creating a run-time library of profiles comprising a master library of profiles and the calculated spectrum data; a storage medium for storing the run-time library; a computer coupled to the master library and the storage medium; and a run-time compiler operable in the computer, for generating the run-time library; wherein the computer activates the run-time compiler to prompt for identification of the selection parameter set, to validate the selection parameter set, to extract the profiles from the master library, and to create a run-time library.

Furthermore, the present invention includes a method for evaluating grating spectrum data, the method comprising comparing a grating spectrum data to the ranges of grating calculated spectrum data in a run-time library; flagging the grating spectrum data as falling within the profile calculated spectrum data ranges in the run-time library or flagging the grating spectrum data falling outside the profile calculated spectrum data ranges in the run-time library; selecting the profile instance in the run-time library whose

calculated spectrum data is closest to the grating spectrum data; and recording the selected profile instance.

Another embodiment of the present invention is a system that invokes a compiler when a set of conditions is met. The system comprises a master library; a starting run-time library compiled with a starting set of trigger conditions; a replacement run-time library, for replacing the starting run-time library; a run-time compiler; a computer; and a comparator operable in the computer, for comparing the calculated set of process trigger values to the starting set of trigger conditions; wherein the comparator, detecting a condition where the calculated process trigger values meet the requirements of the starting set of trigger conditions, automatically invokes the run-time compiler to compile the replacement run-time library.

The present invention also includes a method of providing a service for generating a library of grating profiles, the method comprising contracting by a client and a vendor, where in return for remuneration from the client, the vendor provides access to the systems, processes, and procedures to generate the library or generates and delivers the library.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is an architectural diagram illustrating the dimensions of a grating feature in one embodiment of the present invention.

FIG. 2A is an architectural diagram illustrating the compilation of a master library of grating profiles in one embodiment of the present invention. FIG. 2B is a flow chart of the basic steps in compiling a master library of grating profiles in one embodiment of the present invention.

FIG. 3A is an architectural diagram illustrating the compilation of a run-time library of grating profiles in one embodiment of the present invention. FIG. 3B is a flow chart of the basic steps in compiling a run-time library of grating profiles in one embodiment of the present invention.

FIG. 4 is an architectural diagram illustrating the use of the run-time library to evaluate grating spectrum data in one embodiment of the present invention.

FIG. 5 is a flow chart of the process of using the run-time library to evaluate grating spectrum data in one embodiment of the present invention.

FIG. 6 is an architectural diagram illustrating the automatic compilation of a replacement run-time library in one embodiment of the present invention.

FIG. 7 is a flow chart illustrating the automatic compilation of a replacement run-time library in one embodiment of the present invention.

FIG. 8 is an architectural diagram illustrating a grating profile library generator in one embodiment of the present invention.

FIG. 9 is a flow chart illustrating the use of a grating profile library generator to generate a master library, a run-time library, and a replacement run-time library, in one embodiment of the present invention.

FIG. 10 is a flow chart of the business method of providing a service for generating grating profile libraries in one embodiment of the present invention.

FIG. 11A shows the database elements of a grating profile library in one embodiment of the present invention while FIG. 11B shows the display elements of a grating profile library in one embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT(S)

FIG. 1 is an architectural diagram illustrating the critical dimensions (CD) of a grating feature in one embodiment of the present invention. The cross-sectional view of a feature in a grating has a grating top CD **2**, grating bottom CD **10**, a grating thickness **6**, and underlying thickness **12**. Other dimensions are the width at inflection point **8** and the height at the inflection point **14**. The inflection point **4** is the point in the sidewall of the feature where the slope changes. The percent height at inflection point is defined as the ratio of the height at inflection **14** to the grating thickness **6**. Some applications may include other feature measurements such as the magnitude of T-topping, footing,

rounding, undercut, concave sidewalls, and convex sidewalls as well as the angle of intersection of the sidewall and the underlying thickness.

FIG. 2A is an architectural diagram illustrating the compilation of a master library of grating profiles in one embodiment of the present invention. Parameter input device
5 16 is used to enter a parameter set including the minimum value, maximum value, and the resolution of the dimension of a grating. In alternative embodiments, a parameter set may be created by other input means and specified as the parameter set for a compilation run.

Resolution is the increment by which the parameter dimension changes for the next higher or next lower value. For example, a grating top CD may have a minimum
10 value of 120 nanometers, a maximum value of 180 nanometers, and a resolution of 1 nanometer. Resolution steps is the number of instances of a grating dimension for a given resolution and is calculated using the following formula:

$$\text{Resolution Steps (D)} = ((\text{Maximum Value} - \text{Minimum Value}) / \text{Resolution}) + 1$$

15 where D refers to a dimension of a grating.

In the example above, the resolution steps of the grating top CD would be 61. The number of resolution steps is used to calculate the size of a library.

The compiler 24, operable in the computer 18, uses the specified parameter set to
20 compile a master library and stores it in the output device 22. Optionally, a master library display 20 may be produced. The computer 24 may be one computer or a server farm with a plurality of servers. The computer 24 may be co-located with the parameter input device 16 or may reside at a distributed remote site. The output device 22 may be a CD-ROM drive, a DVD drive, a disk drive, a tape drive, or a remote storage unit.

25 The master library comprises a matrix where the rows are profiles including an instance of a parameter dimension at varying resolutions in combination with the other parameters at varying resolutions and the corresponding calculated spectrum data. Spectrum data refers to the data representing the digitized measurements of the reflected light from a grating. Calculated spectrum data is derived by solving a rigorous

mathematical model of the reflected light from a grating with a given set of parameter dimensions. One such mathematical model is described in "An Integrated System of Optical Metrology for Deep Sub-Micron Lithography", University of California at Berkeley Doctoral Thesis of Xinhui Niu, April 20, 1999, which is incorporated here by reference.

Actual spectrum data may be obtained by using a spectroscopic optical metrology device. Examples of spectroscopic optical metrology devices include spectroscopic ellipsometers and spectroscopic reflectometers.

The size of a compiled master library is a consideration during compilation and during real-time use of the library. For example, the parameter set illustrated in Table 1 would generate a total master library size of 13, 177,728 profiles, representing the combinations of the parameter-dimensions listed in the table at varying resolutions. The size of the library is calculated by multiplying the resolution steps of each dimension, in the above case, the library size is equal to $(16 \times 81 \times 31 \times 4 \times 41 \times 9)$. The first and last three profiles of a master library compiled with the parameter set of Table 1 would be:

Grating Top CD	Grating Bottom CD	Grating Thickness	Percent Height at Inflection Point	Grating Width at Inflection Point	Underlying Thickness	Spectrum data
120	160	220	0.6	140	2.3	Spectra ₁
120	160	220	0.6	140	2.5	Spectra ₂
120	160	220	0.6	141	2.3	Spectra ₃
...
180	200	250	0.9	179	2.5	Spectra _{n1}
180	200	250	0.9	180	2.3	Spectra _{n2}
180	200	250	0.9	180	2.5	Spectra _{n3}

At about 1.5 seconds per profile, the master library of Table 1 would take a server farm of 128 processors about 7 days of CPU time to generate and compile.

FIG. 2B is a flow chart of the basic steps in compiling a master library of grating profiles in one embodiment of the present invention. Initially, the parameter set of a plurality of dimensions for a grating is specified **110**. In one embodiment, the parameter set may be specified by entering the parameters through an input device such as a terminal or PC or it may be specified by identifying a pre-existing file available to the compiler. The pre-existing file may be a file transmitted to the computer or a remote file

accessible to the computer. Next, the compiler compiles a master library of grating profiles based on the specified parameter set **125**. The specified parameter set is edited to ensure the minimum value, maximum value, and the resolution of the dimension are within the ranges established for the application. For example, in one embodiment, the dimensions must be expressed in nanometers. Next, the master library is stored in a storage medium **130**.

FIG. 3A is an architectural diagram illustrating the compilation of a run-time library of grating profiles in one embodiment of the present invention. The system configuration is similar to FIG. 2A. The parameter input device **38** is used to enter a parameter set for the creation of a run-time library **32** from the master library **36**. In alternative embodiments, a parameter set may be created by other input means and specified as the parameter set for a compilation run. The run-time compiler **40**, operable in the run-time computer **30**, edits the parameter set to ensure application edit rules are followed, and creates the run-time library **32**, optionally creating a run-time library display **34**. The run-time library **32** may be stored in a storage medium such as a CD-ROM, a DVD, a disk, a tape, or a remote storage. The computer **30** may be co-located with the parameter input device **38** or may reside at a distributed remote site, accessible to the input device **38** through a public network or dedicated communications lines.

FIG. 3B is a flow chart of the basic steps in compiling a run-time library of grating profiles in one embodiment of the present invention. Initially, the parameter set for run-time library is specified **200**. Table 2 is an example of a parameter set for compiling a run-time library. In one embodiment, the parameter set may be specified by entering the parameters through an input device such as a terminal or PC or it may be specified by identifying a pre-existing file available to the run-time compiler. The pre-existing file may be a file transmitted to the computer or pre-existing file may be a remote file accessible to the computer. The parameter set is validated **210** by applying the application edits. In one embodiment, the run-time compiler edits the parameter set to ensure that the minimum and maximum values of the dimensions are within the ranges of the same dimension in the master library. The parameter set is also edited to ensure that

the resolution is not lower, (i.e., finer resolution) than the resolution used in the master library and that the resolution is a multiple of the resolution used in the master library. Table 3 is an example of a parameter set for compiling a run-time library showing error messages in specifying the resolution. Next, the run-time library is compiled based on the edited parameter set **220**.

FIG. 4 is an architectural diagram illustrating one embodiment using the run-time library to evaluate grating spectrum data. A spectroscopic optical metrology device **50** provides grating spectrum data to profiler application server (PAS) **60**. The profiler application server **60** accesses the run-time library **58** to compare instances of the library with the spectrum data from the spectroscopic optical metrology device **50**. An exception file **54** or an exception display **56** may be created.

FIG. 5 is a flow chart of the process of using the run-time library to evaluate grating profile data in one embodiment of the present invention. The spectrum data of a grating is collected **300**. The collected data may come from spectroscopic optical metrology devices operating real-time or may be from a file containing such data. The spectrum data is received by the profiler application server **310**. The profiler application server accesses the run-time library of grating profiles **320** and determines, based on application criteria, if the grating spectrum data is within the run-time library calculated spectrum data ranges **320**. If the grating spectrum data is outside the run-time library calculated spectrum data ranges, flag the grating spectrum data **330**. Alternatively, if the grating spectrum data is within the run-time library calculated spectrum data ranges, flag the grating spectrum data **340** and select the profile instance that has the calculated spectrum data closest to the grating spectrum data being examined **350**. The closest library spectrum data is one that minimizes the error between the grating spectrum data and the library calculated spectrum data. Several optimization procedures are available to minimize the error, such as simulated annealing, described in "Numerical Recipes," section 10.9, Press, Flannery, Teukolsky & Vetterling, Cambridge University Press, 1986; which is incorporated by reference. The error metric that produces appropriate results is the sum-squared-difference-log error, where the optimization procedure

minimizes the error metric between the grating spectrum data and the library spectrum data.

For example, this process would flag a grating with spectrum data outside the run-time library ranges, due to process drift. Conversely, a grating that is within the run-time library ranges may be flagged, depending on the options chosen for the application.

FIG. 6 is an architectural diagram illustrating the automatic compilation of a replacement run-time library in one embodiment of the present invention. A data entry device 38 is used to enter data processed by the trigger processor 80, which creates a starting trigger file 76. For example, a trigger file may contain data indicating a replacement run-time library 84 is required if the process average change of the grating bottom CD is more than 0.5 after a certain number of manufacturing runs, where:

$$\begin{aligned} \text{Process average change (D)} = \\ & (\text{Library Process Average}_{(D)} - \text{Actual Process Average}_{(D)}) \\ & \div (\text{Library Dimension Range}_{(D)} / 2) \end{aligned}$$

where

$$\text{Library Process Average}_{(D)} = (\text{Library Maximum Value}_{(D)} + \text{Library Minimum Value}_{(D)}) / 2;$$

$$\text{Actual Process Average}_{(D)} = (\text{Actual Maximum Value}_{(D)} + \text{Actual Minimum Value}_{(D)}) / 2;$$

$$\text{Library Dimension Range}_{(D)} = (\text{Library Maximum Value}_{(D)} - \text{Library Minimum Value}_{(D)});$$

and D is the grating dimension.

A spectroscopic optical metrology device 50 collects grating spectrum data and sends this data to profiler application server 60. The profiler application server 60 selects the profile instance from the starting run-time library 58 that has the calculated spectrum data closest to the grating spectrum data from the spectroscopic optical metrology device 50. Depending on the implementation options, the profiler application server 60 may send the grating dimensions data of the selected profile instance from the starting run-time library 58 immediately to the comparator 82 or accumulate the grating dimensions data and wait until a certain period of time has elapsed or until after a predetermined number of manufacturing cycles is completed or until a trigger condition is encountered. The comparator 82 processes the starting trigger file 76 created by the trigger processor

80 and the real-time or batch data dimensions from the profiler application server 60. If the trigger conditions are met, the comparator 82 invokes run-time compiler 40 to generate a replacement run-time library 84. The comparator 82 also creates a replacement trigger file 78 to be used as the starting trigger file in the next auto compilation cycle. The run-time compiler 40 uses the master library 36 as input, the data from the comparator 82 and the starting parameter set 88 to create the replacement run-time library 84 and to create a replacement parameter set 89. The replacement parameter set 89 becomes the starting parameter set in the next auto compilation cycle. In an alternative embodiment, the profiler application server 60 and the computer 86 may be a single computer device.

FIG. 7 is a flow chart illustrating the automatic compilation of a replacement run-time library in one embodiment of the present invention. Based on the application, the client selects one or more trigger conditions that must be met for an auto-compilation to be invoked. This starting set of trigger conditions is specified 400. Grating spectrum data is received and the profile instance from the starting run-time library that has the calculated spectrum data closest to the grating spectrum data is selected 410. The starting trigger condition values are evaluated when the application criteria require the evaluation to be done 420. For example, the application criteria may require evaluation of the trigger condition values after a specific number of manufacturing runs are completed or when a predetermined time interval has elapsed. The starting trigger conditions are compared to the starting trigger condition values and if the conditions are met 430, a replacement trigger file and a replacement run-time parameter set are created 440. The replacement run-time library is compiled based on the replacement run-time parameter set 450. The replacement trigger file is set as the starting trigger file and the replacement parameter is set as the starting parameter set 460.

For example, a run-time library is compiled with the grating bottom CD having a minimum value of 180 nanometers (nm) and a maximum value of 200 nm; thus, the run-time library has a bottom CD process average of 190 nm, $(180+200)/2$. The starting set

of trigger conditions entered for this application is that a replacement run-time library is compiled anytime the change in the grating bottom CD process average exceeds 0.5.

After a manufacturing run of 2,000 wafers, the comparator **82** detected that the calculated actual process average for the grating bottom CD changed from 190 nm to 183 nm due to process drift. The grating bottom CD process average changed by 0.7, as shown in the following calculation:

$$\text{Process average change (Bottom CD)} = [(190-183) \div (200-180)/2] = 0.7.$$

Since the bottom CD process average change of 0.7 is greater than the trigger condition of 0.5, the comparator **82** would invoke the run-time compiler **40** to use the starting parameter set **88**, create a replacement parameter set **89** with the grating bottom CD having a minimum value of 173 nm and a maximum value of 193 nm. A replacement run-time library **84** would be compiled by the run-time compiler **40** using the replacement parameter set **89** and the master library **36** as input. The comparator **82** would create a replacement trigger file **78** with a process average of 183 nm. If after another manufacturing run of 1500 wafers, the comparator again detected a shift of the grating bottom CD process average, the process of evaluating the trigger condition values and compilation of the replacement run-time library would be repeated. Table 4 is the example of a replacement parameter set created for the automatic compilation of the run-time library, triggered by the change in the grating bottom CD process average exceeding 0.5.

FIG. 8 is an architectural diagram illustrating a grating profile library generator. A requestor device **92** sends a request for a grating profile library to the library generator **94** operable in computer **98**. The library generator **94** creates the library and stores the library in output device **96** and sends a response to requestor device **92**. The requestor device **92** and the output device **96** may be located in separate remote locations from the computer **98**. The links between the requestor device **92** and the output device **96** to the computer **98** may be a network, such as the Internet. The computer **98** may be one

computer or a server farm. The requestor device **92** and the output device **96** may be in the same unit.

FIG. 9 is a flow chart illustrating the use of a grating profile library generator to generate a master library, a starting run-time library, and a replacement run-time library, in one embodiment of the present invention. A request for generating a type of grating library is entered **500**. The library type entered in the request is determined **510**. If the request is for a master library, the master library is compiled **520**; if the request is for a run-time library, the run-time library is compiled **530**, otherwise if the request is for a replacement run-time library, a replacement run-time library is compiled **540**. In all cases where there is a successful compilation, the compiled library is stored in a storage medium or a file is created for network processing **550**, where the stored library is transmitted to the client or downloaded by the client.

FIG. 10 is a flow chart of the business method of providing a service for generating grating profile libraries in one embodiment of the present invention. The client and the vendor contract for the vendor to provide a service regarding grating profile libraries **600**. The type of service contracted may be a network service, package service or product service **610**. For a network service, an account is created for the client by the vendor to provide library generation service through a network **620**, such as the Internet. For a package service, the vendor provides a package of software, procedures, and or hardware to the client **630**. For a product service, the vendor obtains information for the type of library desired and the vendor provides the generated library product **640** to the client. The client may be an organization with many agents, assignees, or licensees. In all instances, the vendor obtains remuneration for the services provided **650**.

FIG. 11A shows the database elements of a grating profile library while FIG. 11B shows the display elements of a grating profile library.

There are many advantages for the current invention. The creation of the master library allows a one-time generation of wide ranges, resolutions, and shapes of grating profiles and associated spectrum data, without the need for the laborious empirical measurements. The creation of a run-time library allows for the generation of the specific

geometries and shapes of the grating profiles needed for a specific manufacturing window. The size of the run-time library is kept small to facilitate quick search times. Fabricators can re-center their libraries into smaller dimensions or make minor changes to the underlying thickness and get the library response time required for real-time work.

5 Foregoing described embodiments of the invention are provided as illustrations and descriptions. They are not intended to limit the invention to precise form described. In particular, it is contemplated that functional implementation of invention described herein may be implemented equivalently in hardware, software, firmware, and/or other available functional components or building blocks.

10 Other variations and embodiments are possible in light of above teachings, and it is thus intended that the scope of invention not be limited by this Detailed Description, but rather by Claims following.

Parameter	Minimum, nanometer (nm)	Maximum, nanometer (nm)	Resolution, nanometer (nm)
Grating Top Critical Dimension (CD)	120	180	1
Grating Bottom CD	160	200	0.5
Grating Thickness	220	250	1
Percent Height at Inflection Point	0.6	0.9	0.1
Grating Width at Inflection Point	140	180	1
Underlying Thickness	2.3	2.5	0.2

TABLE 1 - Parameter Set for Compiling a Master Library

Parameter	Minimum, nm	Maximum, nm	Resolution, nm
Grating Top Critical Dimension (CD)	140	160	1
Grating Bottom CD	180	200	0.5
Grating Thickness	230	240	1
Percent Height at Inflection Point	0.8	0.9	0.1
Grating Width at Inflection Point	150	170	1
Underlying Thickness	2.3	2.5	NA

TABLE 2 - Parameter Set for Compiling a Run-Time Library

Parameter	Minimum, nm	Maximum, nm	Resolution, nm
Grating Top Critical Dimension (CD)	140	160	1
Grating Bottom CD	180	200	0.25 Resolution too high
Grating Thickness	230	240	1
Percent Height at Inflection Point	0.8	0.9	0.25 Resolution is not a correct multiple
Grating Width at Inflection Point	150	170	1
Underlying Thickness	2.3	2.5	NA

TABLE 3 - Parameter Set for Compiling a Run-Time Library Showing Edit Errors

Parameter	Minimum, nm	Maximum, nm	Resolution, nm
Grating Top Critical Dimension (CD)	140	160	1
Grating Bottom CD	173	193	0.5
Grating Thickness	230	240	1
Percent Height at Inflection Point	0.8	0.9	0.1
Grating Width at Inflection Point	150	170	1
Underlying Thickness	2.3	2.5	NA

- 5 TABLE 4 - Replacement Parameter Set for Automatic Compilation of a Run-Time Library Triggered by a Change in the Grating Bottom CD Process Average Exceeding Trigger Conditions

CLAIMS

What is claimed is:

1. A method of creating a master library of grating profiles, the method comprising:

5 specifying a parameter set including a plurality of dimensions of a grating; and
compiling a master library of profiles, the profiles including data representing combinations of grating dimensions in the specified parameter set and corresponding calculated spectrum data.

10 2. The master library profile creation method of Claim 1, wherein the parameter set including the plurality of dimensions of the grating comprises a minimum value, a maximum value, and a resolution for a dimension of the plurality of dimensions of the grating.

15 3. The master library profile creation method of Claim 2, wherein the plurality of dimensions of the grating comprises a grating top critical dimension, a grating bottom critical dimension, a grating thickness, and an underlying thickness.

20 4. The master library profile creation method of Claim 3, wherein the plurality of dimensions of the grating further comprises a percent height at inflection point and a grating width at inflection point.

5. The master library profile creation method of Claim 1, further comprising storing the master library of grating profiles in a storage medium.

25 6. The master library profile creation method of Claim 5, wherein the storage medium for the master library of grating profiles comprises a CD-ROM, a magnetic tape, a magnetic disk, and a file available for network use.

7. The master library profile creation method of Claim 6, wherein the master library of grating profiles available for network use is transmitted to clients or downloaded by clients.

5 8. A system for creating a master library of grating profiles comprising:
a storage medium for storing the master library of grating profiles; and
a computer coupled to the storage medium; and
a compiler operable in the computer, for creating the master library of grating profiles;

10 wherein the computer activates the compiler to create the master library, the compiler prompting specification of a parameter set of grating dimensions, the compiler validating the specified parameter set, the compiler creating the master library of grating profiles, based on the validated parameter set, and corresponding calculated spectrum data, and the compiler storing the master library of grating profiles in the storage medium.

15 9. The master library profile creation system of Claim 8, wherein the computer is a server farm.

20 10. The master library profile creation system of Claim 8 further comprising an input device, coupled to the computer, for entering the parameter set of grating dimensions for the master library of grating profiles.

25 11. The master library profile creation system of Claim 8, wherein the storage medium for storing the master library of grating profiles comprises a CD-ROM, a magnetic tape, a magnetic disk, and a file available for network use.

12. The master library profile creation system of Claim 11, wherein the file available for network use is transmitted to clients or downloaded to clients.

13. The master library profile creation system of Claim 12, wherein the file of grating profiles comprises a database of grating profiles and a run-time compiler.

14. A system for creating a run-time library of grating profiles comprising:
5 a master library of grating profiles;
a storage medium for storing the run-time library;
a computer coupled to the master library and the storage medium; and
a run-time compiler operable in the computer, for generating a run-time library of grating profiles;

10 wherein the computer activates the run-time compiler to generate the run-time library, the compiler prompting for specification of the selection parameter set, the compiler validating the specified selection parameter set, the compiler extracting the profiles from the master library of grating profiles, the compiler creating the run-time library of grating profiles, and the compiler storing the run-time library in the storage
15 medium.

15. The run-time library creation system of Claim 14, wherein the specified selection parameter set comprises a specified minimum value, a specified maximum value, and a specified resolution value of the grating dimensions.

20 16. The run-time library creation system of Claim 15, wherein validation of the specified selection parameter set comprises checking that the specified minimum value and specified maximum value of the grating dimension are within the minimum value and maximum value of the corresponding dimension in the master library, and that the
25 specified resolution value of the grating dimension is the same or higher than the resolution value for the master library for the corresponding dimension in the master library, and that the specified resolution value for the dimension is a multiple of the resolution value of the master library for the corresponding dimension in the master library.

17. The run-time library creation system of Claim 14 further comprising an input device, coupled to the computer, for specifying the selection parameter set for the run-time library.

5

18. The run-time library creation system of Claim 14, wherein the storage medium for storing the run-time library of grating profiles comprises a CD-ROM, a magnetic tape, a magnetic disk, and a file available for network use.

10

19. The run-time library creation system of Claim 14, wherein the run-time library comprises a database of grating profiles and a file containing a process average of each dimension of the grating.

15

20. A database format for storing grating profiles, the database format comprising:

- a grating top critical dimension;
- a grating bottom critical dimension;
- a grating thickness; and
- calculated spectrum data.

20

21. The database format of Claim 20, wherein the grating top critical dimension, grating bottom critical dimension, and grating thickness are expressed in nano meters.

25

22. A display format of grating profiles, the display format comprising:
- a grating top critical dimension;
 - a grating bottom critical dimension;
 - a grating thickness; and
 - calculated spectrum data.

23. A method for evaluating grating spectrum data, the method comprising:
comparing a grating spectrum data to ranges of grating calculated spectrum data in
a run-time library;

flagging the grating spectrum data as falling within the calculated spectrum data
5 ranges in the run-time library or flagging the grating spectrum data as falling outside the
calculated spectrum data ranges in the run-time library; and

selecting the profile instance in the run-time library whose calculated spectrum
data is closest to the grating spectrum data.

10 24. The grating spectrum data evaluation method of Claim 23 further comprising
recording the selected the profile instance in the run-time library whose calculated
spectrum data is closest to the grating spectrum data.

25. A system for evaluating grating profile data comprising:

15 a spectroscopic optical metrology device for generating grating spectrum data;
a run-time library of grating profiles; and

an profiler application server coupled to the spectroscopic optical metrology
device and the run-time library, for comparing the grating spectrum data to instances of
calculated spectrum data in the run-time library and for selecting the profile instance in
20 the run-time library whose calculated spectrum data is closest to the grating spectrum
data;

wherein the spectroscopic optical metrology device communicates the grating
spectrum data to the profiler application server; the profiler application server accesses
the run-time library; flags the grating spectrum data if the grating spectrum data is outside
25 the ranges of the calculated spectrum data in the run-time library or flags the grating
spectrum data if the grating spectrum data is within the ranges of the calculated spectrum
data in the run-time library and selects the profile instance in the run-time library whose
calculated spectrum data is closest to the grating spectrum data.

26. A method of automatically compiling a replacement run-time library of grating profiles, the method comprising:

specifying a set of trigger conditions that causes compilation of a replacement run-time library of grating profiles; and

5 compiling the new run-time library of grating profiles whenever the set of trigger conditions is met.

27. The automatic compilation of a replacement run-time library method of Claim 26, wherein the set of trigger conditions comprises one or more process averages of

10 parameter-dimensions exceeding corresponding predetermined amounts or percentages.

28. The automatic compilation of a replacement run-time library method of Claim 26, wherein the set of trigger conditions is evaluated after a specified length of time has elapsed or after a predetermined number of gratings is manufactured.

29. A system for automatically compiling a replacement run-time library of grating profiles, the system comprising:

a master library of grating profiles;

15 a starting run-time library of grating profiles compiled with a starting set of trigger conditions causing compilation of a profile library;

a replacement run-time library of grating profiles, for replacing the starting run-time library of grating profiles when compiled;

a run-time compiler for compiling the replacement run-time library of grating profiles;

25 a computer coupled to the master library and the starting run-time library; and

a comparator operable in the computer, for calculating actual process values and comparing the calculated actual process values to the starting set of trigger conditions;

wherein the comparator, detecting a condition where the calculated actual process values meet the requirements of the starting set of trigger conditions, invokes the run-time compiler to compile the replacement run-time library of grating profiles.

5 30. The automatic run-time library compilation system of Claim 29, wherein the starting set of trigger conditions is evaluated after a specified length of time has elapsed or after a predetermined number of gratings is manufactured.

10 31. A system for generating a library of grating profiles comprising:
a parameter set for specifying a type of library of profiles and for specifying
ranges and resolutions of dimensions of gratings;
a computer; and
a library generator, operable in the computer, for compiling a plurality of libraries
of profiles, the profiles including data representing combinations of grating dimensions in
15 the specified parameter set and corresponding calculated spectrum data;
wherein the library generator creates a master library of profiles when the type of
library specified by the parameter set is for the master library and creates a run-time
library of profiles when the type of library specified by the parameter set is for the run-
time library.

20 32. A method of providing a service for generating a library of grating profiles,
the method comprising:

contracting by a client and a vendor, for the client to remunerate the vendor for the
use of the systems, processes, and procedures to generate a library of grating profiles; or
25 for the delivery of libraries of grating profiles to the client; and in return for the
remuneration from the client, for the vendor to provide access to the systems, processes,
and procedures for generating the library of grating profiles for the client or for the
vendor to generate and deliver a library of grating profiles to the client;

providing by the vendor to the client access to the systems, processes, and procedures to generate the library of grating profiles; and

using by the client or by the assignees, beneficiaries, or licensees of the client the systems, processes, and procedures to generate the library of grating profiles.

5

33. A computer storage medium storing the computer readable code for causing a computer system to execute the steps of generating a library of grating profiles, the steps comprising:

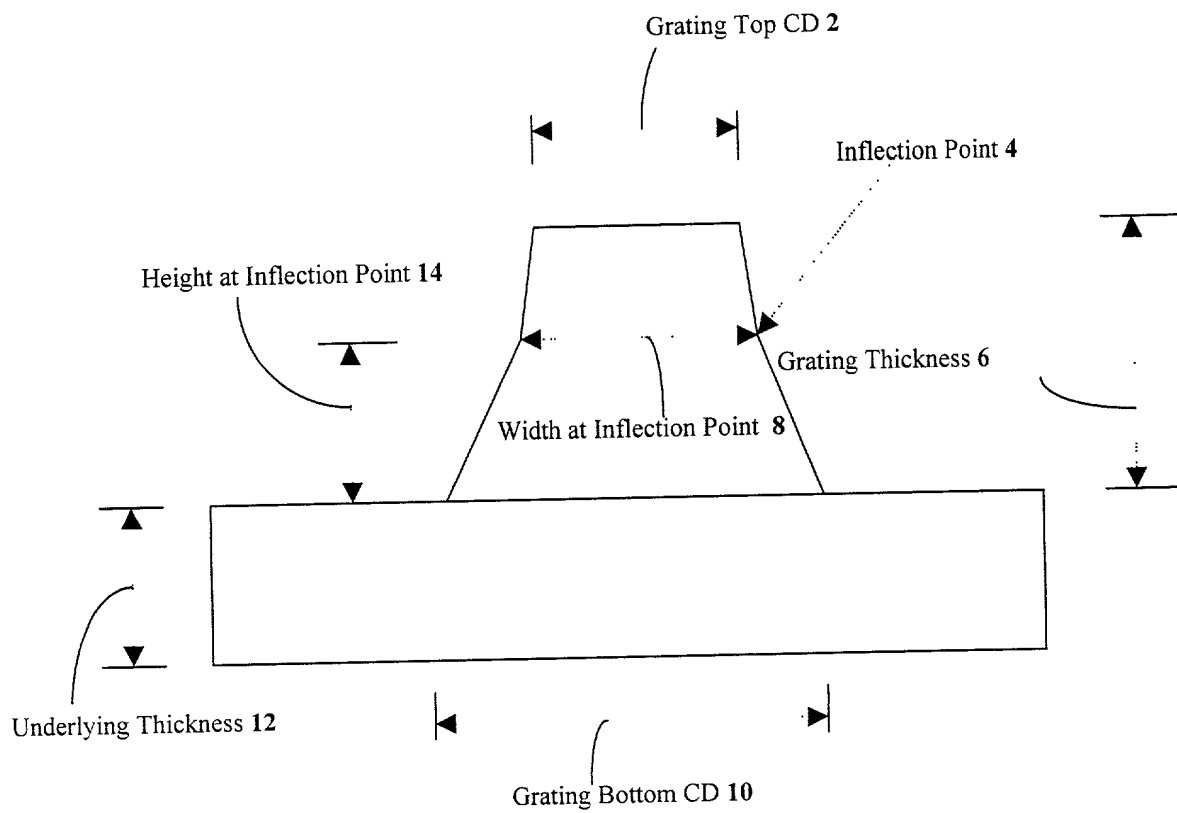
specifying a parameter set for a type of library of grating profiles ; and

10

compiling the type of library of grating profiles corresponding to the specified parameter set, wherein the profiles include data representing combinations of grating dimensions in the specified parameter set and corresponding calculated spectrum data.

ABSTRACT

5 The present invention provides a method and a
system for a real-time configurable definition and
generation of grating profile libraries. A parameter set is
used to specify the ranges of grating dimensions and
resolutions of the profile library to be generated. In one
10 embodiment, a compiler creates subsets of a large profile
library, the subset designed to enable rapid search and
validation of real-time data. In another embodiment, an
automatic process generates a new parameter set and a new
subset of the library when trigger conditions are met.
15 Subsets of the profile library may be used to check if
grating spectrum data are within the ranges established for
an application and if the dimensions are within the process
averages established for a manufacturing run. The system
for generation of grating profile libraries is scalable,
20 operable in a distributed environment, and includes
application specific items that can be selected or
determined by the client.



11/20/00

FIGURE 1

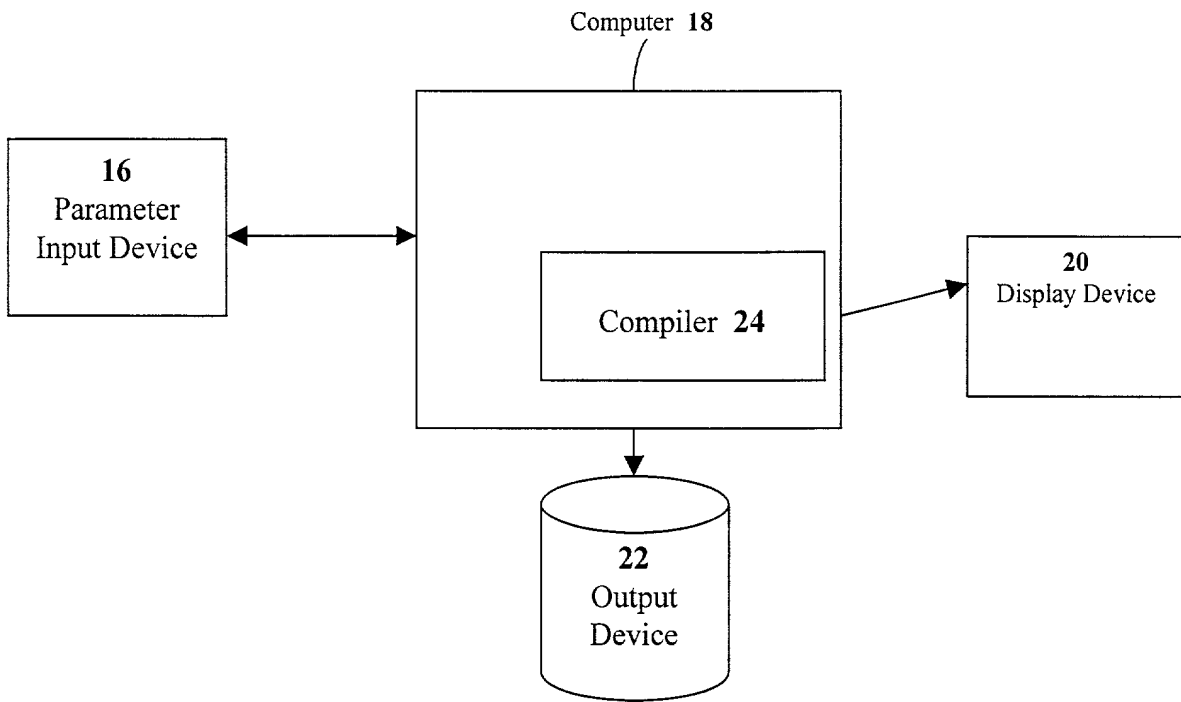


FIGURE 2A

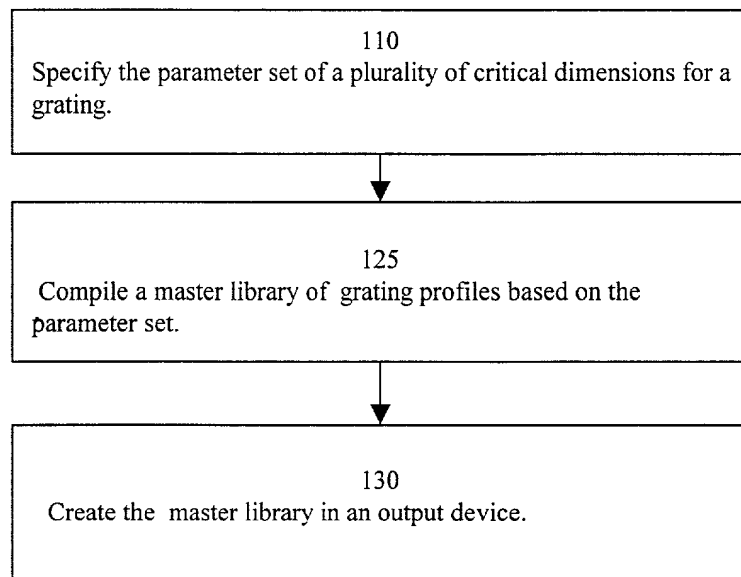


FIGURE 2B

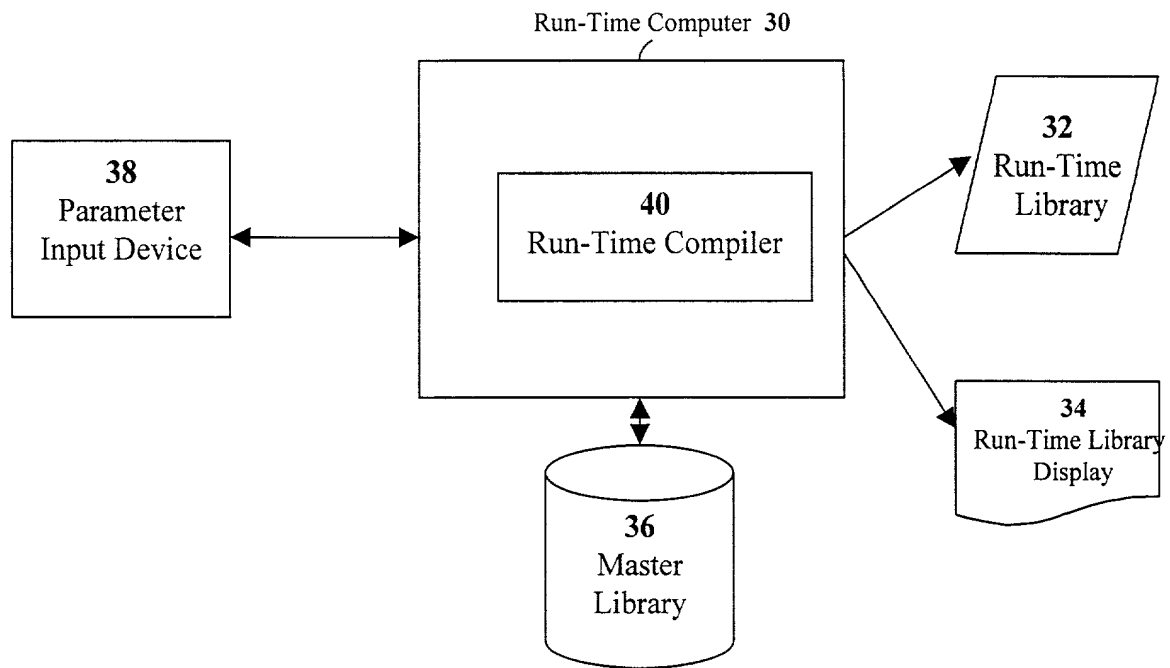


FIGURE 3A

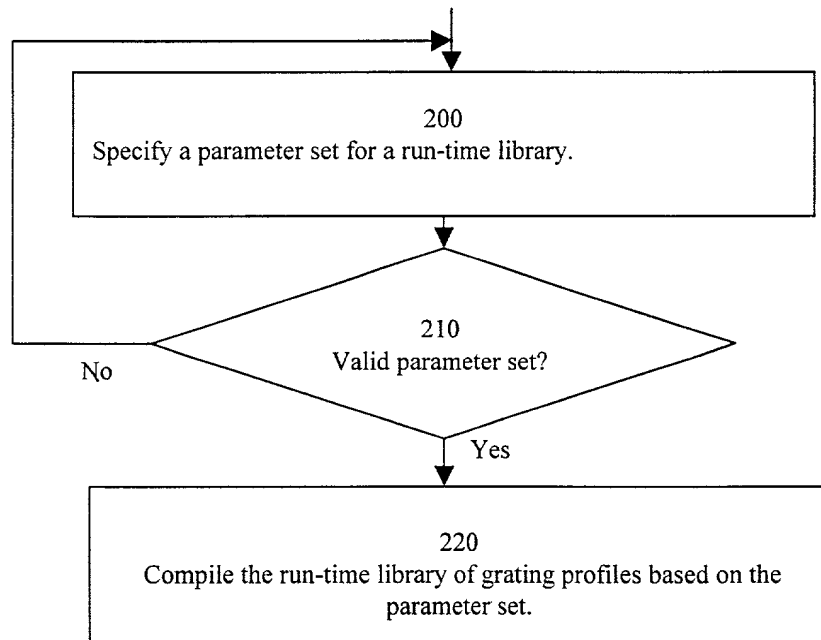


FIGURE 3B

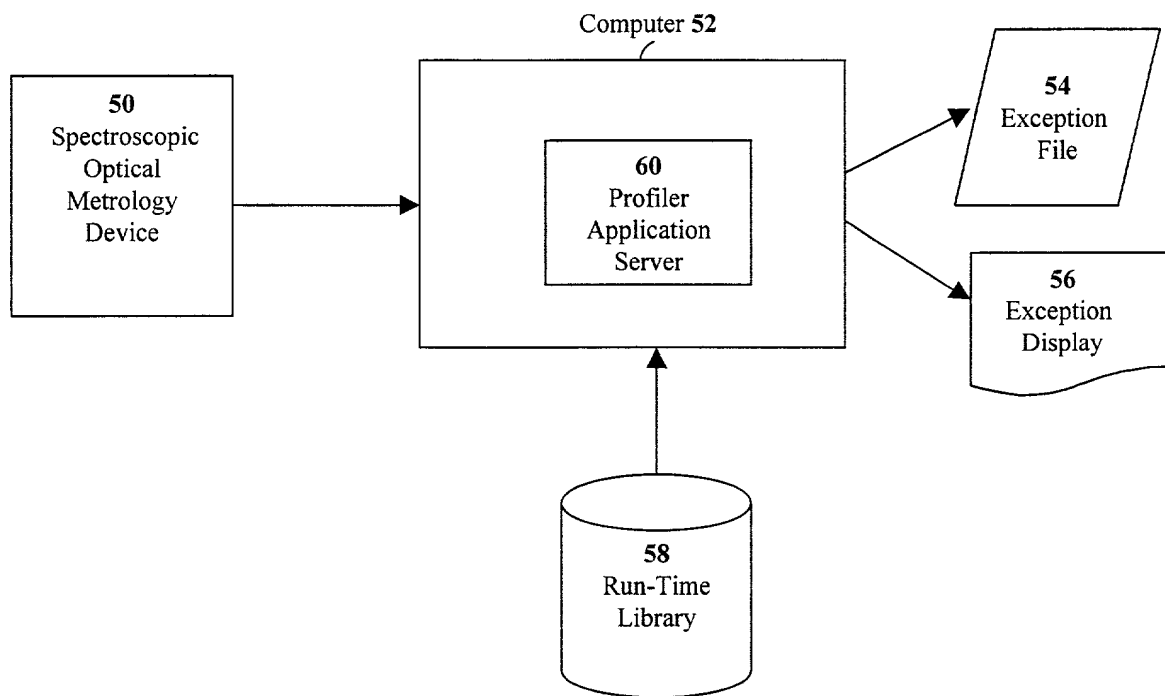
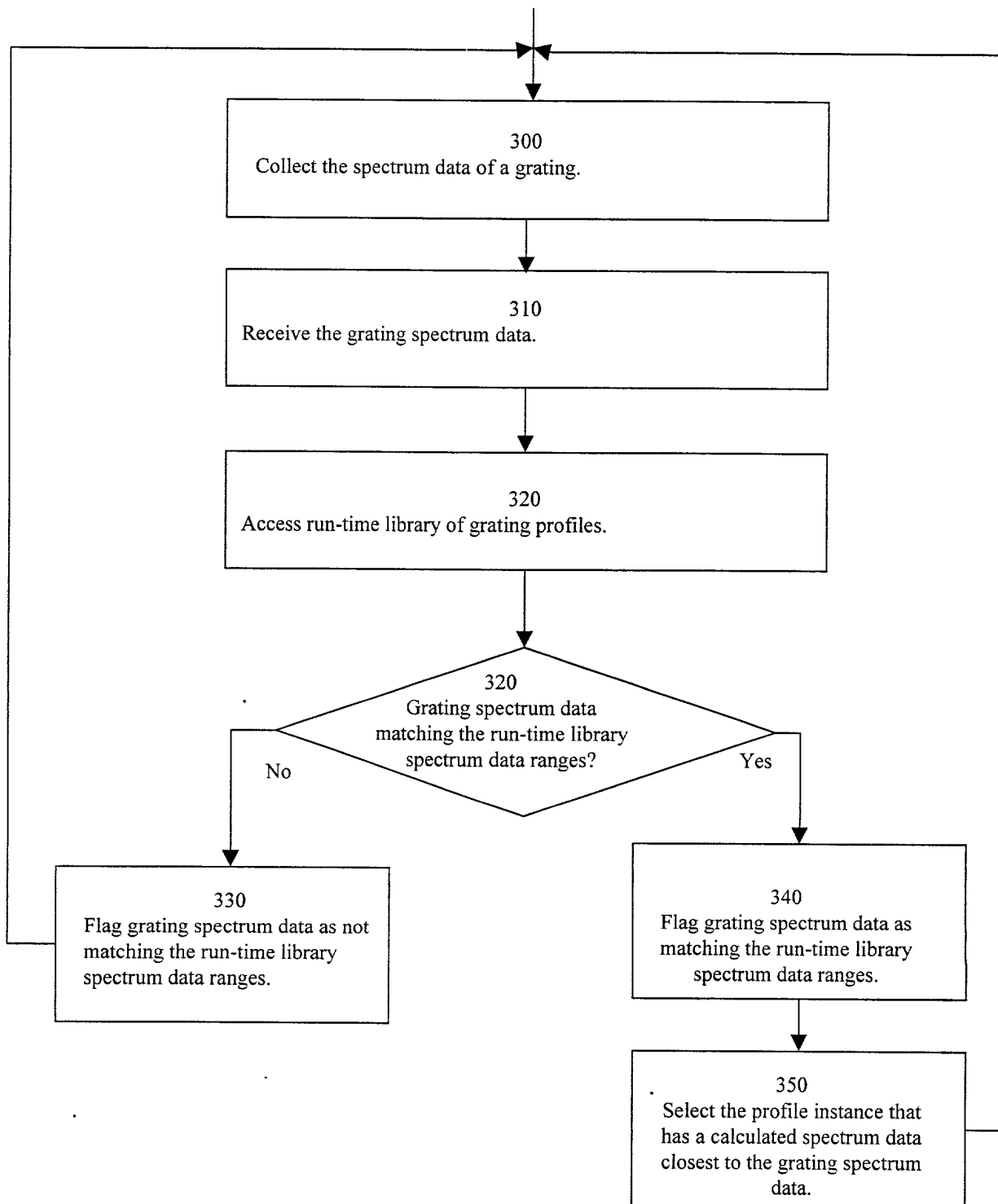


FIGURE 4



11/20/00

FIGURE 5

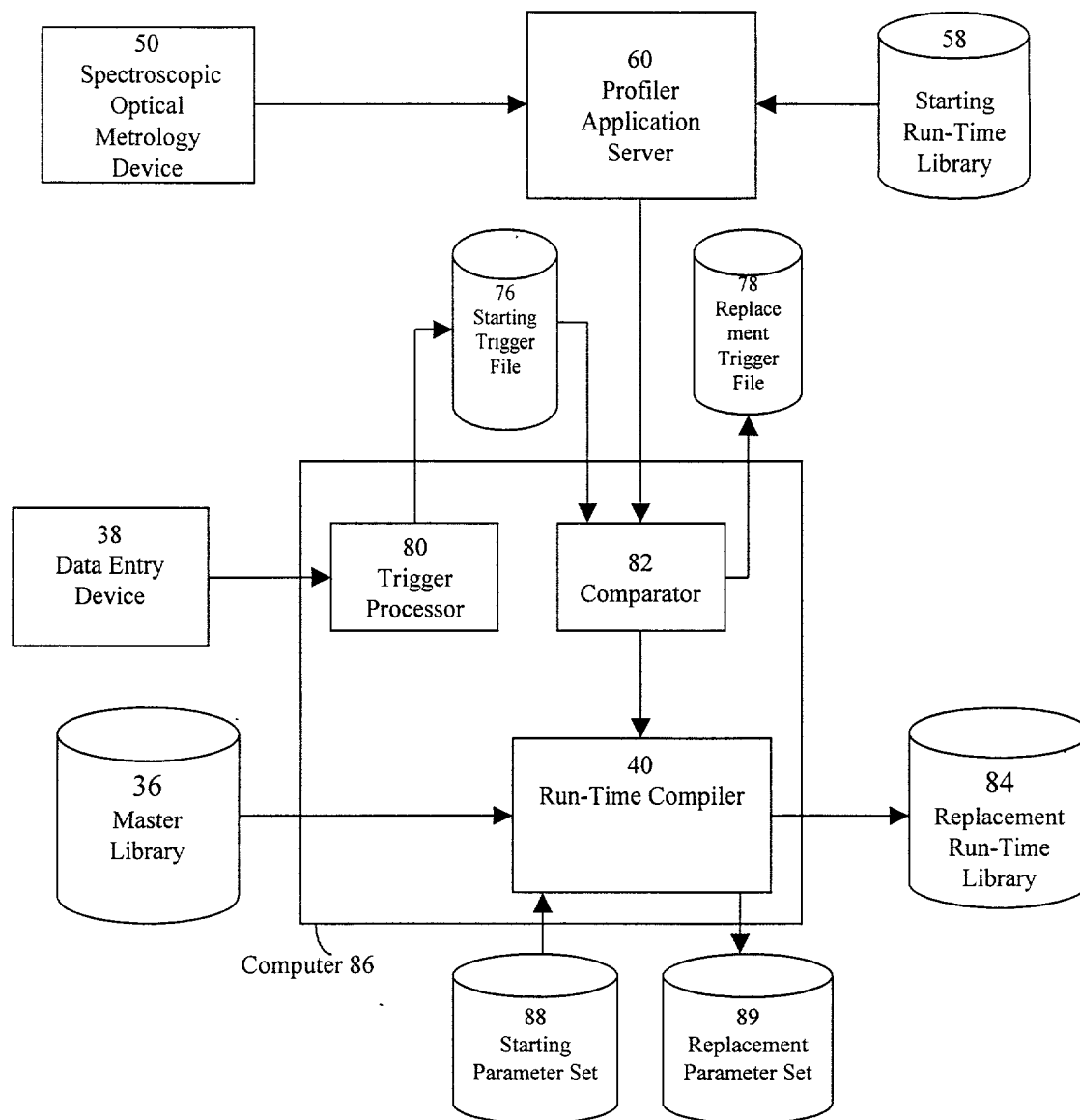


FIGURE 6

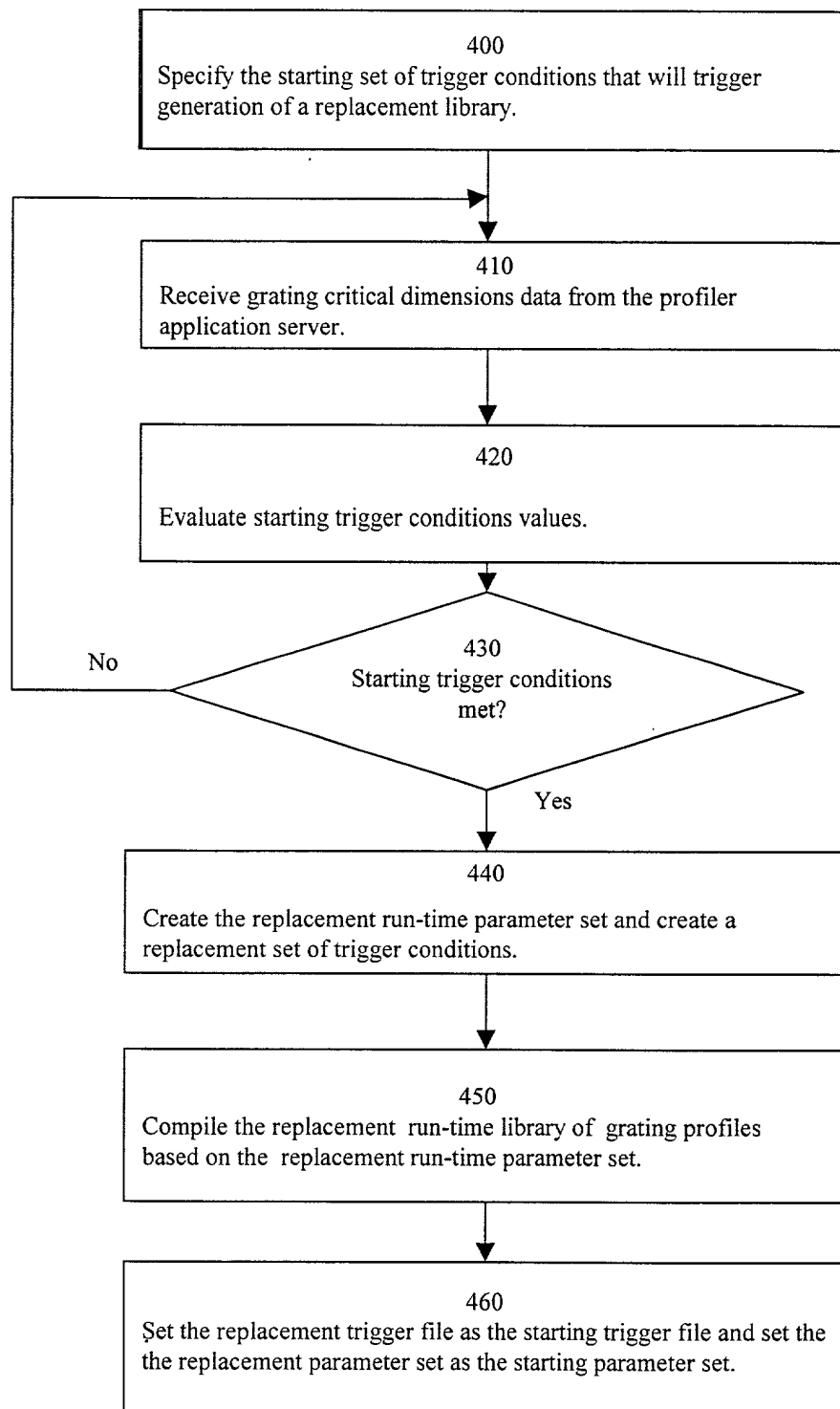


FIGURE 7

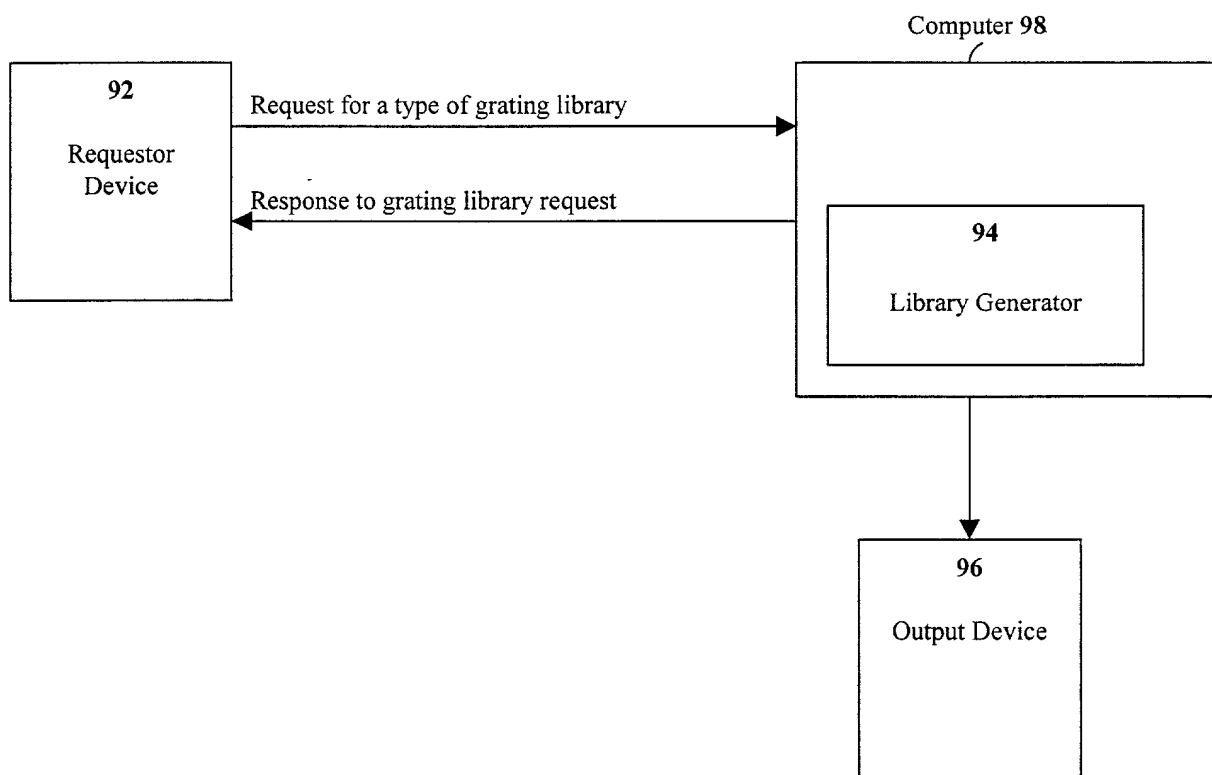


FIGURE 8

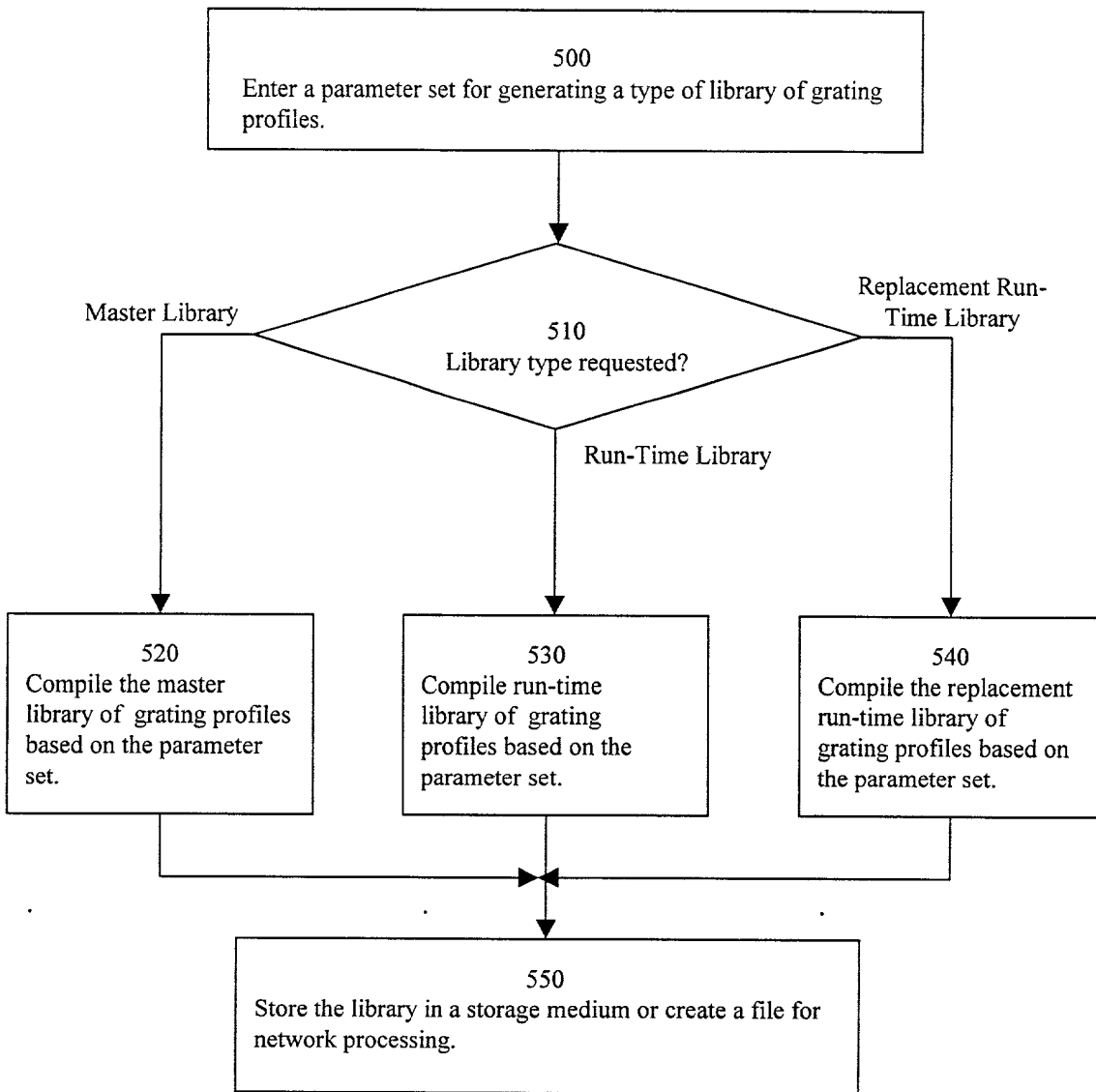


FIGURE 9

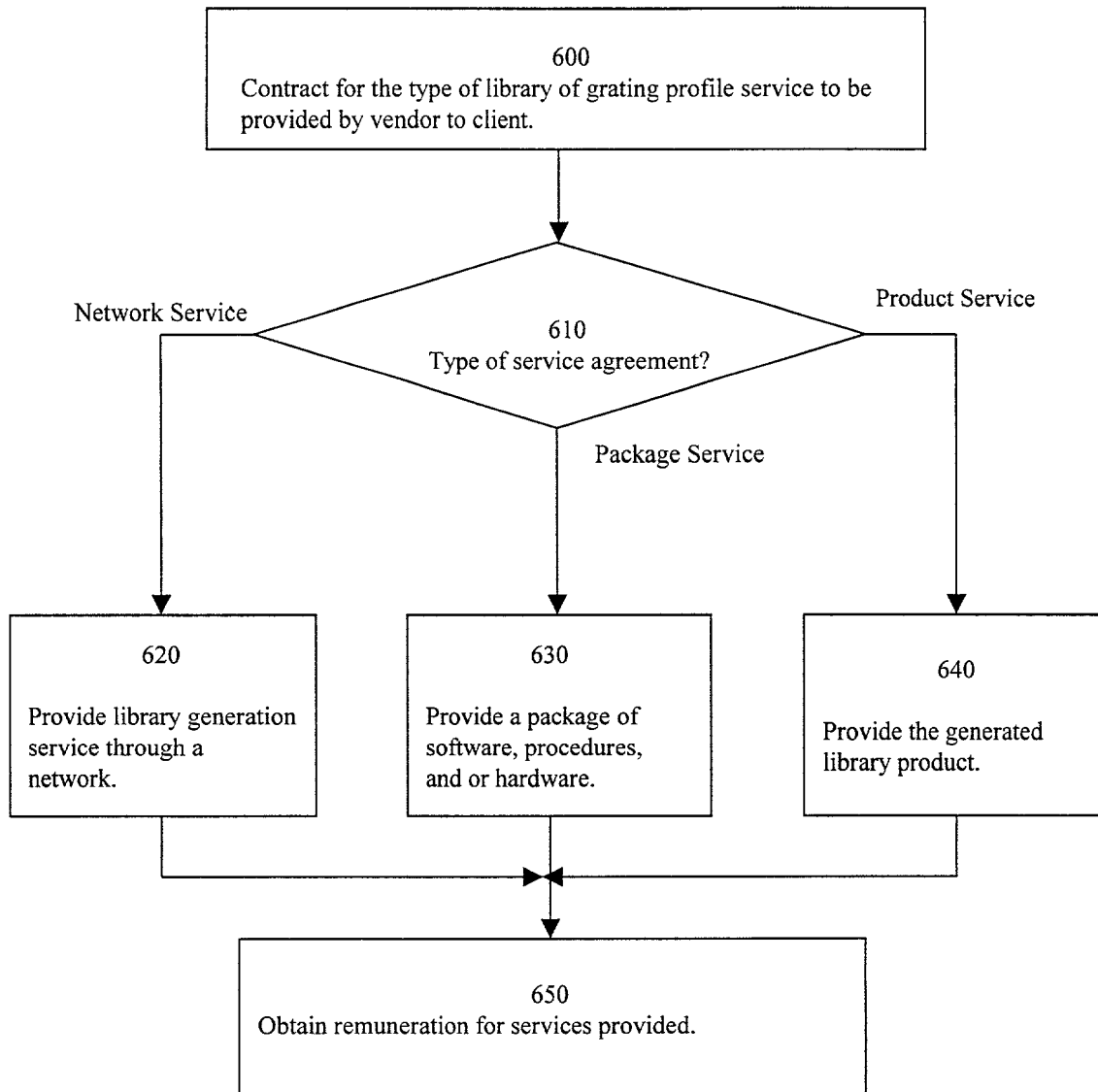


FIGURE 10

Grating Top CD	Grating Bottom CD	Grating Thickness	Percent Height at Inflection Point	Grating Width at Inflection Point	Underlying Thickness	Calculated Spectrum Data
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FIGURE 11A - DATABASE ELEMENTS OF A GRATING PROFILE LIBRARY

Grating Top CD	Grating Bottom CD	Grating Thickness	Percent Height at Inflection Point	Grating Width at Inflection Point	Underlying Thickness	Calculated Spectrum Data
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FIGURE 11B - DISPLAY ELEMENTS OF A GRATING PROFILE LIBRARY

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, postal address and citizenship are as stated below next to my name.

I believe that I am the original, first and sole inventor (if only one name is listed below) or an original first and joint inventor (if multiple names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

“SYSTEM AND METHOD FOR REAL-TIME LIBRARY GENERATION OF GRANTING PROFILES”

the specification of which is attached hereto unless the following information is indicated:

_____ was filed on _____;
as United States Application Number or PCT International Application Number _____;
and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendments referred to above.

I acknowledge the duty to disclose information that is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified, as so indicated below, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Claimed

(Application No.)

(Country)

(Day/Month/Year Filed)

___ Yes ___ No

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

(Application No.)

(Day/Month/Year Filed)

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information that is material to patentability as defined in 37 C.F.R. 1.56 that became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application No.)

(Day/Month/Year Filed)

(Status - patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the United States Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and beliefs are believed to be true; and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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